International Journal of Electrical and Electronics Engineering (IJEEE)
ISSN(P): 2278-9944; ISSN(E): 2278-9952
Vol. 3, Issue 2, Mar 2014, 7-18

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

AUTOMATED HOME OR OFFICE ELECTRIC CONTROL SYSTEM

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ABSTRACT

In the present global scenario, with the raising standards and increasingly dynamic life styles, people are becoming more forgetful about their energy consumption, resulting in increasing electricity bills, which causes worry. At a juncture where energy crisis is one of the most pressing issues of the hour, there is a dire need for a new technology solution to handle this kind of energy wastage. This paper presents a prototype to automate switching on and off of lighting systems and extends the functionality by allowing remote control through DTMF in order to conserve electrical energy.

KEYWORDS: Automated, Conservation, Optimization, Embedded System, Occupancy Sensors, DTMF

INTRODUCTION

The problem statement addressed in this paper is the electricity wastage caused by leaving the electrical appliances in the ON state despite not being in use. The simplest yet most overlooked way of electrical energy conservation is by switching off of the electrical appliances when not required. Occupancy sensors are a convenient way to eliminate the forgetfulness of people when it comes to turning the lights off [1]. Occupancy sensors are devices that can detect movement within a defined space, such as a bedroom, office room, waiting room, rest room etc. Only when movement is detected will these sensors light the area to which they correspond [2]. However, occupancy sensors cannot be used to facilitate switching ON and OFF of electrical appliances like air conditioner, heater. In order to help one control the entire electric system of the home or office from a remote location, DTMF technology comes to use.

PROPOSED SYSTEM

This system can be implemented using a PIC microcontroller (say PIC 16F877A), a Real Time Clock, an occupancy sensor (say PIR motion sensor), LDR sensor, DTMF decoder, and a relay circuit. A PIR motion sensor is used to detect human activity within the sensor's range [4]. These types of sensors are made of Pyroelectric sensors, which detect different levels of Infrared Radiation in the surrounding. Apart from Pyroelectric sensors, a group of supporting circuits combined with some resistors and capacitors will be there in the sensor package. It also contains Micro Power PIR motion Detector IC within it, which takes the output of the sensor and does some minor processing on it to emit a digital output pulse from the analog sensor. The following diagram shows the connection diagram of PIR sensor with PIC.

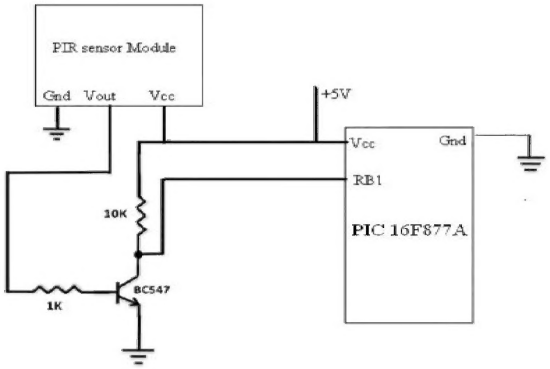

Figure 1: Connection Diagram of PIR Sensor with PIC Microcontroller

A DTMF keypad (generator or encoder) generates a sinusoidal tone which is a mixture of the row and column frequencies. The row frequencies are low group frequencies [3]. The column frequencies belong to high group frequencies. This prevents misinterpretation of the harmonics. Also the frequencies for DTMF are so chosen that none have a harmonic relationship with the others and that mixing the frequencies would not produce sum or product frequencies that could mimic another valid tone. The high-group frequencies (the column tones) are slightly louder than the low-group to compensate for the high-frequency roll off of voice audio systems.

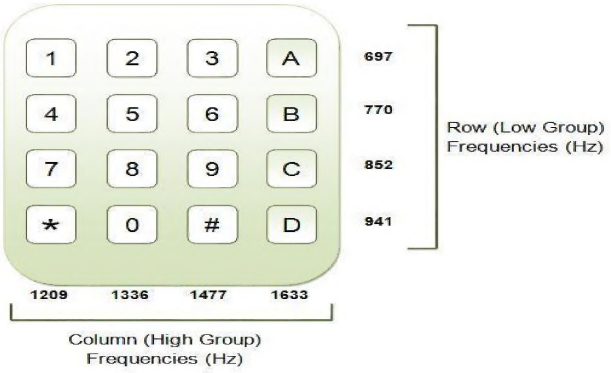

Figure 2: DTMF Keypad

The row and column frequencies corresponding to a DTMF keypad have been indicated in the above figure.

DTMF tones are able to represent one of the 16 different states or symbols on the keypad. This is equivalent to 4 bits of data, also known as nibble. The following diagram shows the circuit diagram of DTMF.\

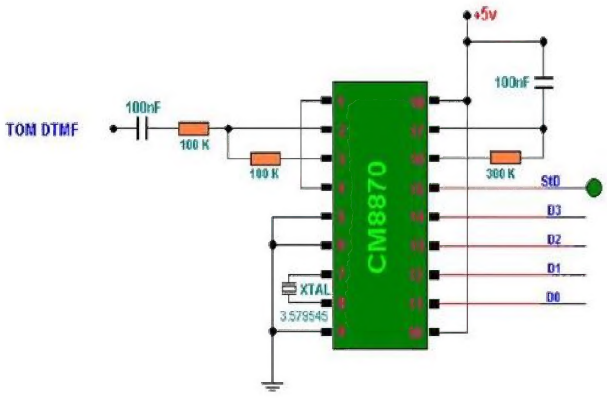

Figure 3: Circuit Diagram of DTMF

The proposed system consists of two modules – one of occupancy sensing using PIR sensor while other is that of DTMF, both using PIC microcontroller.

SYSTEM ARCHITECTURE

The following diagram shows block diagram of the Occupancy Sensing System

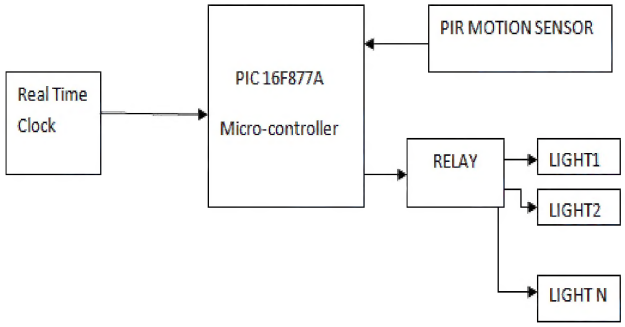

Figure 4: Block Diagram of Occupancy Sensing Module

The Microcontroller PIC 16F877A takes input from the PIR motion sensor and gives the output to the Relay circuit. This relay circuit is connected to the lights and controls the switching ON/OFF mechanism. The real time clock is used to check what time of the day it is. If it is day time and the ambient light is sufficient enough, then the lights are not switched ON even when a person enters a room. However, if the ambient light intensity is not enough, then the lights are switched ON when a person enters the room. If there is no occupancy detected, the lights are switched OFF. The ambient light intensity can be measured using LDR sensor.

The diagram below shows the Block Diagram of DTMF based Home Control System:

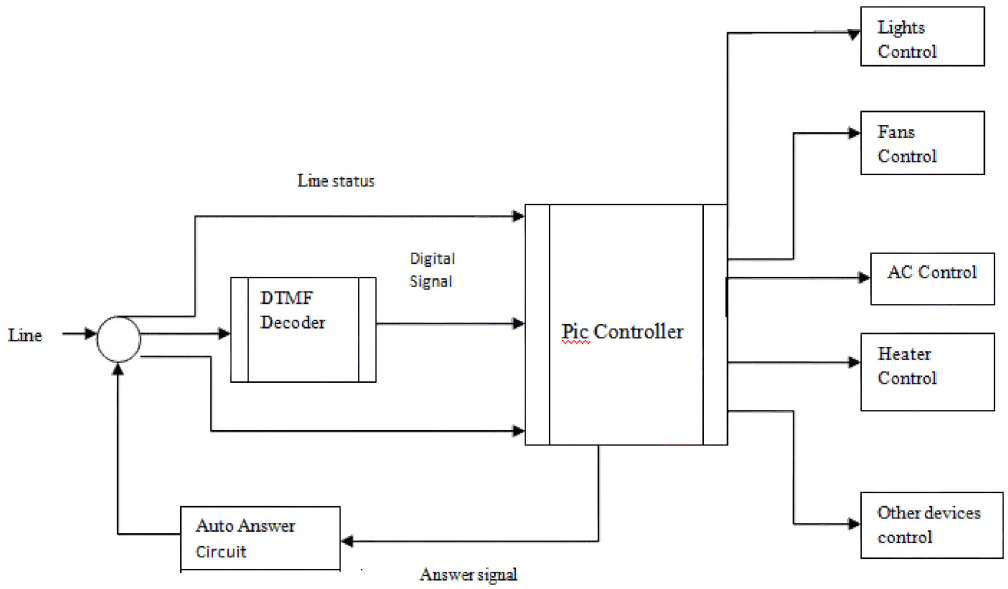

Figure 5: Block Diagram of the DTMF Based Electric Control System

The above system uses a PIC microcontroller 16F877A. The output from the DTMF decoder is a digital signal. This is interpreted by the microcontroller which in turn drives the relay circuit and then controls the lights/ fans/ AC/ heater and/ or other devices as required.

PROPOSED ALGORITHM

The following algorithm explains the procedure used for Occupancy sensing using sensors and DTMF based remote control of the home or office electrical system

- Start
- Check whether any occupant is there in the room using PIR motion sensor.
- If occupancy is detected (i.e. Occupancy sensor output is high), then check the current time from real time clock.
- If the time is day, then check the ambient light density using LDR sensor. If the ambient light is above a pre-defined threshold, then the light is not switched ON.
- However, if it is below a pre-defined threshold, then connect the relay such that the lights will be switched ON.
- If the time is night, then the lights are not switched ON. However, this setting can vary from room to room. In rooms other than bedrooms, the system can be programmed to turn ON the lights if occupancy is detected during night time.
- Go to step 1 again.
- If occupancy is not detected (i.e. occupancy sensor output is low), then the lights are switched OFF irrespective of the time of the day.
- After some time delay, go to step 1 again
- Define DTMF as Interrupt Service Routine (ISR) and program suitable procedures.
- Stop.

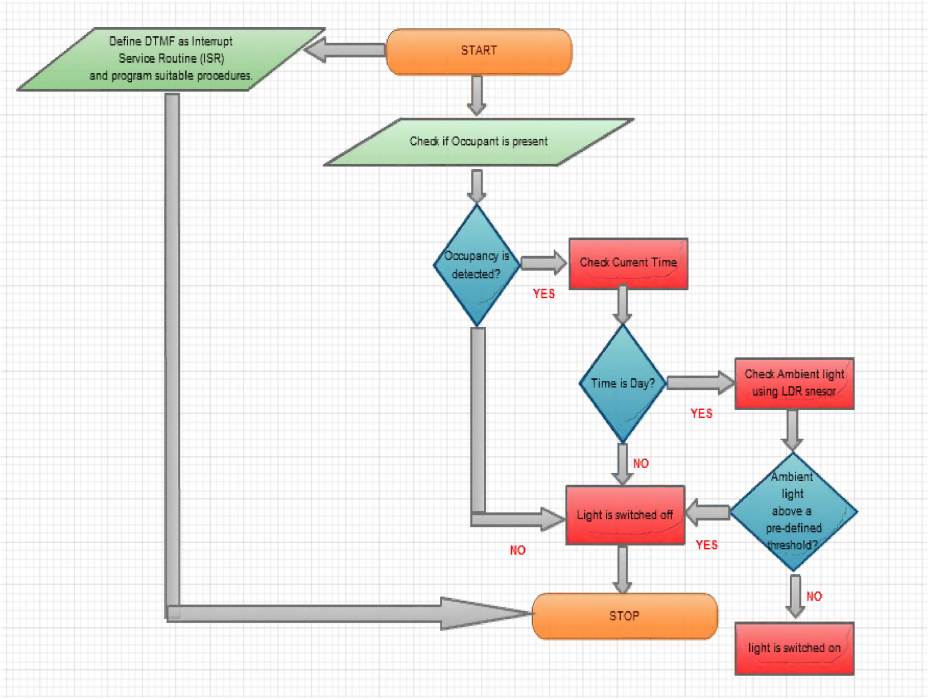

Figure 6: Flowchart Showing Algorithm Used in the Proposed System

HARDWARE IMPLEMENTATION

The hardware implementation is done using the PIC development Board and the relay circuit is used to switch ON/OFF the lights and/or fans. The PIC development board is where the microcontroller is used for the PIR sensor to function and to supply the input to the relay circuit. This system can be implemented using a PIC 16F877A, a Real Time Clock, a PIR sensor, LDR sensor, DTMF decoder and the relays which are going to control the lights.

Relay Circuit

A relay is an electrically operated switch. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. It is also used when the load is high and the capacity of the load is higher than the capacity of the board/Device. The relay circuit is used to run heavy loads like a motor. We have used the relay circuit for the functioning of the light and the fan. The Circuit diagram of the Relay Circuit is shown in the figure below.

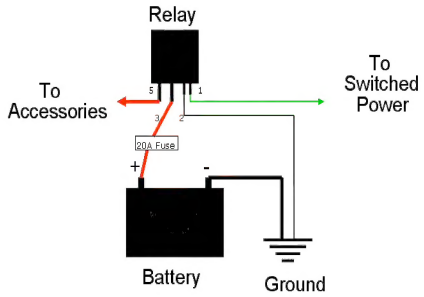

Figure 7: Circuit Diagram of the Relay Circuit

Description of the Circuit

- Pin 1 of the relay circuit is connected to the power supply (12 V).
- Pin 2 is connected to the ground.
- Pin 3 is connected to the positive terminal of the battery through a 20A fuse.
- The Negative terminal of the Battery is grounded.
- Pin 5 is connected the accessories (Light, Fan).

The following diagram shows the bottom view of the relay circuit.

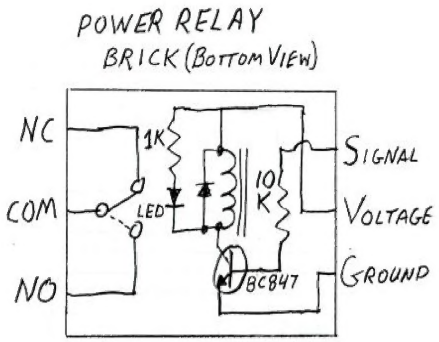

Figure 8: Bottom View of the Relay Circuit

Legend

- NC- Normally Closed
- NO- Normally Open
- COM- Common
- Resistor- 1k
- BC 847- Transistor
- Diode- 1N4001

Detailed Description of Components

- **PIR Sensor Specifications**
  - **Power Requirements:** 3.3 to 5 VDC; >3 mA (may vary)
  - **Communication:** Single bit high/low output
  - **Operating Temperature:** 32 to 122 °F (0 to 50 °C)
  - **Dimensions:** 1.27 x 0.96 x 1.0 in (32.2 x 24.3 x 25.4 mm)
- **PIC 16f877 a Microcontroller Features**
  - **Pin Count:** 40-pin PDIP
  - **Program Memory:** 14KB or 8K 14-bit Flash
  - **Max Crystal Speed:** 20MHz
  - **RAM Bytes:** 368
  - **EEPROM Bytes:** 256
  - **Timers:** 2 x 8 bit, 1 x 16-bit
  - **Digital Communication:** 1xA/E/USART, 1 x MSSP(SPI/I2C)
  - **Capture/Compare/PWM:** 2 x CCP
  - **ADC:** 8ch, 10-bit
  - **Comparators:** 2
- **Relay Board**
  - PCB(Printed Circuit Board)
  - Integrated Circuit(IC L293D)
  - 12 V bulb
  - 12 V Fan

- Connecting Wires
- Relay Circuit

- **PIN Diagram of IC L293D**
  - The Output from the PIC development Board is fed as an input to the IC (L293D).
  - Pin 4, 5, 13, 14 are grounded.
  - Power Supply of 12V is given to the IC.
  - The IC is connected to the Relay Circuit to switch ON/OFF the light and fan.

The following diagram shows the PIN Diagram of IC L293D

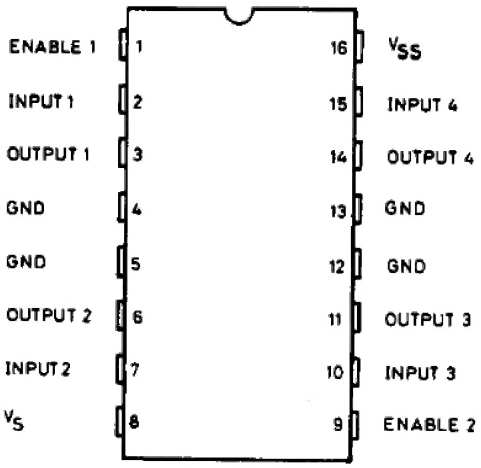

Figure 9: PIN Diagram of IC L293D

HARDWARE MODEL

The following diagram shows the complete prototype of the proposed occupancy sensing system

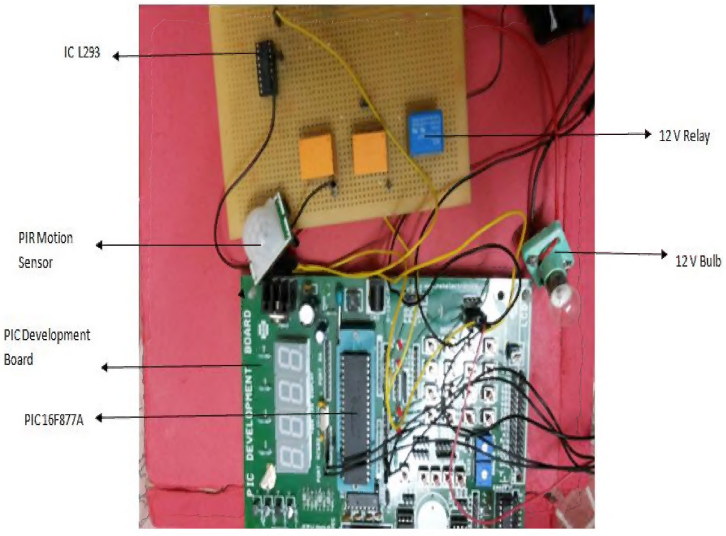

Figure 10: Hardware Model of the Proposed Occupancy Sensing System

The following diagram shows a snapshot of the working prototype of the proposed system with the Occupancy sensing and DTMF modules integrated. The switching ON/ OFF of lights and fans is simulated using LEDs on the PIC Development Board

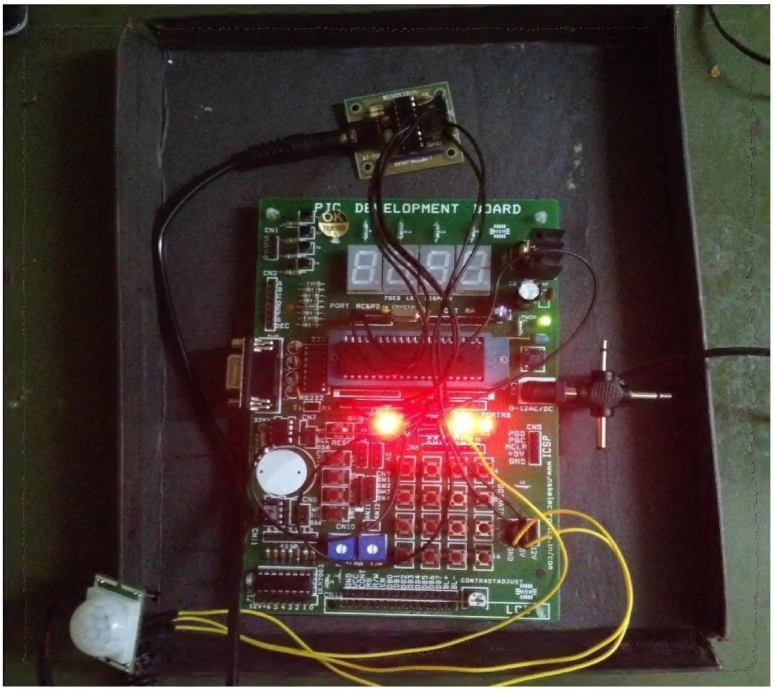

Figure 11: Working Prototype of the System with Occupancy Sensing and DTMF Module

FEASIBILITY ANALYSIS

DTMF technology is a very easy-to-use and user friendly way of automating home/office control systems. The DTMF technology was observed to show brilliant results. It allows the user to control up a whole lot of functionalities which can vary from switching ON/OFF a heater to switching ON/OFF the air conditioner. All of this is possible on a key press on a mobile call. This can be secured by adding a security pin to be entered before entering the actual key to control the home/office electric control system. Hence, the system is a very secured and convenient way of remotely controlling the power system at office or home.

Determining the basic energy savings potential across applications requires establishing a baseline of observed occupancy and lighting conditions [5]. Lighting and occupancy use in any space will always fall into one of the following four conditions:

- Occupied with the lights on
- Occupied with the lights off
- Unoccupied with the lights on
- Unoccupied with the lights off

Of the four conditions, the first three are of particular interest. Condition one is of interest for garnering information about how frequently occupants use these types of spaces with the lights on. Conditions two and three are of interest when considering lighting controls.

If occupants frequently occupy a space without requirement for lighting (condition two), then a manual lighting control device that allows occupants to turn lights off may be provided. Condition three represents wasted lighting energy by having lights on when spaces are unoccupied [1]. This condition is of primary importance when considering using automatic occupancy sensor control [7].

Using PIR sensors for occupancy sensing is a smart way to save energy consumption by switching off the lights and/or fans when no one is present around [7]. A small survey was done on the pattern of energy consumption pattern of single-bedded, double-bedded, four bedded and six-bedded rooms in a hostel setup.

Performance Analysis of installing Occupancy sensors is given as under:

Site 1: Hostel Rooms

In the current setup (from real world data collected at ladies hostel in VIT University, Vellore, Tamil Nadu, India):

Average number of hours electricity is being wasted in a day

In a single bedded room = 3.6 hours

In a double bedded room = 3.4 hours

In a four bedded room = 3.2 hours

In a six bedded room= 3 hours

Assuming an efficiency of 80 % for PIR motion sensor (to take into account the time delay and sensitivity setting), average number of hours energy can be saved per day:

For single bedded room =2.88 hours (1 tube light)

For double bedded room = 2.72 hours (1 tube light)

For four bedded room= 2.56 hours (2 tube lights)

For six bedded room =2.36 hours (3 tube lights)

Total number of hours electricity saved per day from 4 rooms = (2.88 + 2.72+ 2.56*2 +2.36*3) = 17.8 hours

Total amount of energy saved per day from 4 rooms = 17.8 * 40 Wh= 712 Wh

Total amount of energy saved per month from 4 rooms = 712 *30 Wh = 21,360 Wh= 21. 36 KWh

Cost of electricity per KWh = Rs 4.5 (average)

Total amount saved in a month from 4 rooms= Rs. 4.5 * 21.36 =Rs. 96.12

Total amount saved in a year from 4 rooms = Rs. 96.12 *12 = Rs. 1153.44

Since, the range of detection is up to 15 feet, if the PIR sensor is mounted at a strategic location, it will cover the entire room in its field of coverage for all the types of rooms.

Assuming the total installation cost of each sensor = Rs. 524/-

Number of sensors to be installed = Total no. of rooms =x (say)

For the system to be economically feasible, the saving >= Investment

Hence, Rs.1153.44 * x /4 * n >= Rs.524 *x

where n is the payback period in years and x is the total number of rooms.

n is found to be approximately 1.81 years.

Hence, payback period = 1.81 years

Thus, the system is found to be feasible.

Site 2: Washrooms in Offices

Installation cost of each sensor= Rs. 524/-

Number of sensors to be installed= 356

Total installation cost of sensors= 356*524=Rs.186544

Total energy consumed= 2095.16 kWh/day

Energy savings due to installation of sensors=0.3*2095.16=628.5 kWh/day

Estimated energy savings=295*628.5 =185407.5 kWh/year

Estimated savings of energy= Rs. 3457/day

Total saving in a year= 3457*295 (working days) =0.102 crores/year

Payback period= 186544/3457=53.96 days~ 2 months

CONCLUSIONS AND FUTURE ENHANCEMENTS

Motion sensors using passive infrared (PIR) detection have been around for many years. Using PIR motion sensors to detect occupancy in a closed space and thus using its output to switch on or switch off the light is a highly intelligent way of saving up energy consumption.

The occupancy sensor-based lighting control system has several advantages listed as under:

- Functions as promised; that is, it turns the lights on and keeps them on whenever anyone is present and turns the lights off and keeps them off when no one is present
- This can be made to vary and customized by the programmer as per the specific needs of the customer.
- Delivers immediately measurable and verifiable savings
- Is cost effective
- Has significant positive environmental and social benefits
- Will provide significant long-term savings as electricity costs are only predicted to rise over the next 10 years and Return on Investment (ROI) is estimated to be less than two years.

Overall, occupancy sensor-based lighting control systems are considered attractive to businesses and residential places from the multiple perspectives of upfront cost, electricity savings, ROI, positive social and environmental impact and good corporate governance.

Dual-tone multi-frequency signalling (DTMF) is used for telecommunication signaling over analog telephone lines in the voice-frequency band between telephone handsets and other communications devices and the switching center. There are several advantages of using DTMF technology for automating home/ office control system. Some of these are listed below:

Higher Security

Using DTMF for obtaining user input is more secure and gives owners the assurance that sensitive data is being protected. DTMF tones cannot be interpreted by the human ear, but can be easily decoded by a phone system and computer. Thus sensitive information can be isolated from the agents as well as from call recording systems. In the absence of DTMF, an agent with a malicious intent can steal sensitive information.

Improved Metrics

Obtaining user inputs via DTMF can improve the key metrics such as Average Handling Time (AHT), since the agents need not reply back to the caller to confirm the accuracy of the input. The increased security offered by DTMF also improves the customer satisfaction levels as they feel more comfortable entering sensitive data using DTMF, thus maintaining its anonymity. In addition to this, scheduling heavy loads during peak usage periods across neighbourhoods will help bring energy costs down and reduce wastage.

Reduced Probability of Errors

It also reduces the possibility of errors as there is only one point of data entry. DTMF was originally designed to use the frequencies in the normal human voice range. As a result it can easily pass over normal two way radio channels, narrow band and wide band. DTMF is a straight forward technology that is easy to understand, compatible with most equipment and can be used to provide the most cost effective and flexible features. It does not require expensive equipment or special channel for transmitting the frequencies.

As pulse dialing is nearly reached the end of its lifespan and voice recognition engines still have a long way to go, DTMF solutions seem to be the answer for home automation system.

This system can be enhanced further by extending to multiple applications controlled by the same system. For example, a single module could control energy usage, garage doors, heating and cooling units, cooking units, etc resulting in an intelligent automated system. The system can also be made capable of handling sudden surge of current or voltage using a stabilizer.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Arun Kumar T for his constant guidance and support for this project. They would also like to thank Prof. Siva Rama Krishna Somayaji for his mentoring and constructive criticism throughout this research work.

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